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(56) Documents Cited by ISA
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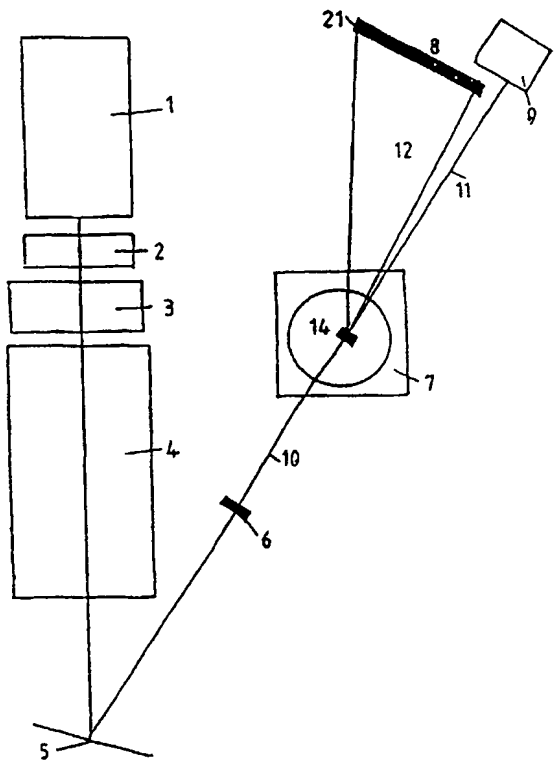
(54) Abstract Title
Method and device for reading-out holographically stored information

(57) The invention relates to a method for reading-out holographically stored information from a storage medium, especially a crystal. The aim of the invention is to provide a simple means of reading-out which avoids defects and has very few requirements in terms of the environmental conditions. A processed beam (10) of coherent electromagnetic radiation is sent through the storage medium (14) that contains the information. The intensity of the transmitted component (11) of the beam (10) is measured. The position of the storage medium (14) which is mounted on the turntable (7) is changed by means of a control device (19) in such a way that the intensity of the transmitted component (11) of the beam (10) is minimised. The information from the deflected component (12) of the beam (10) is read out by means of a camera device (8). The invention also relates to a device for carrying out said method.



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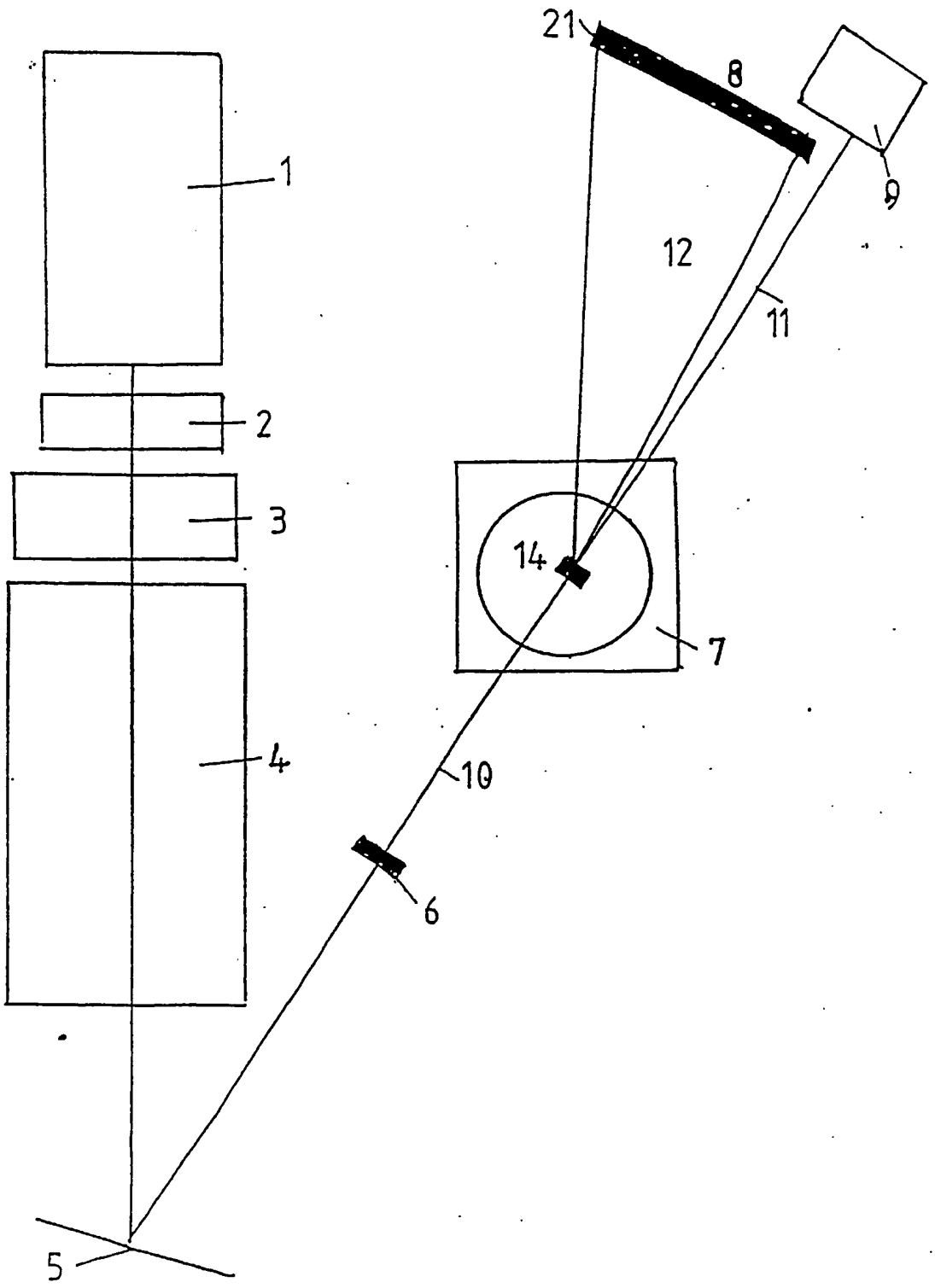

Fig 1

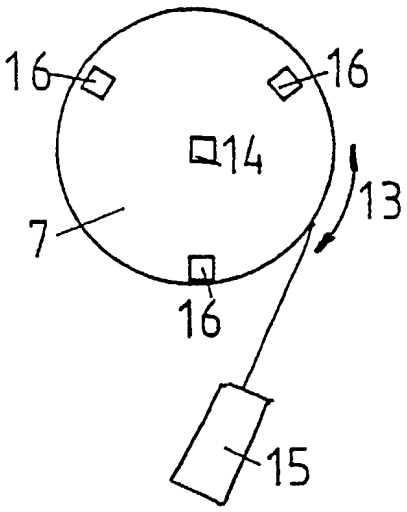

Fig 2

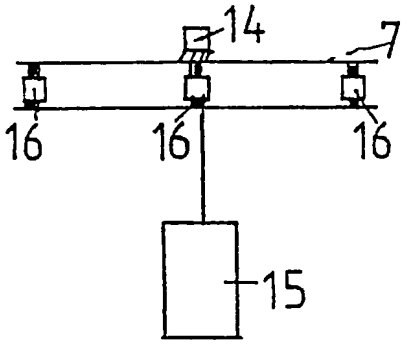

Fig 3

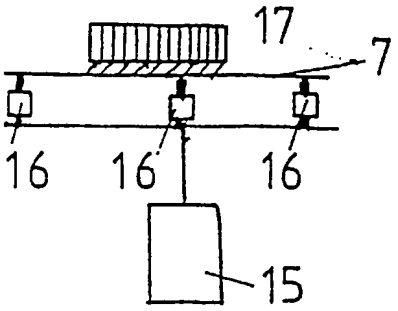

Fig 4

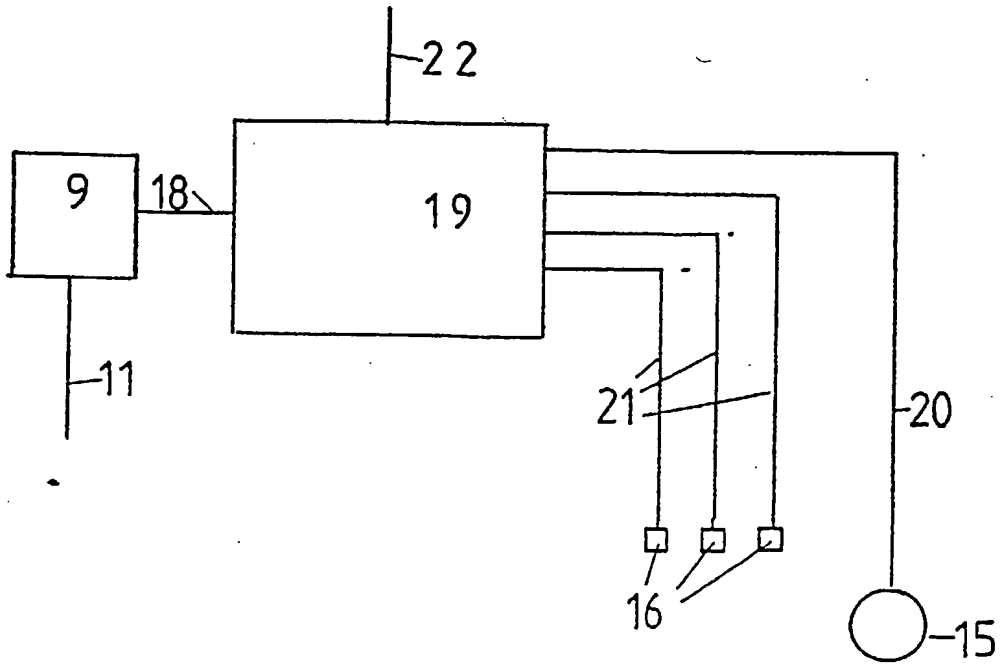

Fig 5

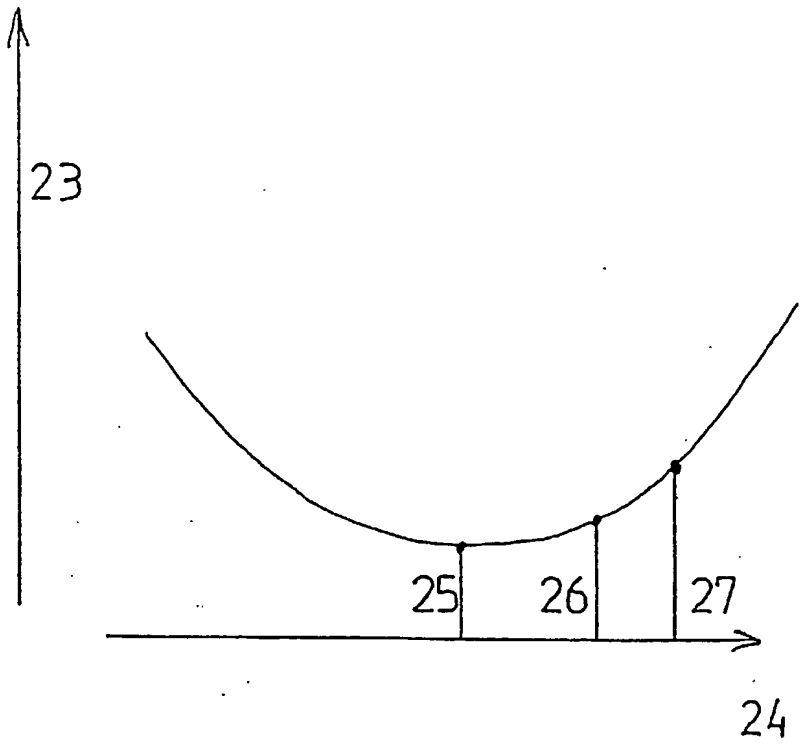

Fig 6

A method and a device for reading out holographically stored information

The invention relates to a method for reading out holographically stored information comprising the features of the preamble of Claim 1 and also a device comprising the features of the preamble of Claim 3.

In commercial but also in technical data processing, information, i.e. analogue image information or digital data, is stored in great volumes. The storage of this information is essentially in magnetic memories such as tapes, diskettes and hard disks, but also on CD-ROMs and magneto-optical discs. Storage in holographic storage media is also possible in principle.

When information or data are stored in magnetic memories, such as tapes, diskettes and hard disks, a loss of data is apt to occur. This loss of data occurs in any case through the period of storage as the magnetic properties of the material change over the course of time. Because of this, these data stores must be read out after about 6 years and re-written again afresh. The equipment has only very low electromagnetic compatibility. Magnetic fields, such as those produced by standard commercial magnets or by electric currents, are enough to erase or change the data and thereby make them unusable. Raised temperatures, such as those occurring during storage under the effect of sunlight, are also enough to change the data. For this reason considerable technical and organisational effort is needed to protect the data carriers.

Even the newer CD-ROMs only guarantee data integrity for up to 20 or 30 years.

Even on these data carriers a loss of data occurs with higher temperatures. The order of magnitude of the stored data on a data carrier of the aforementioned type is below 100 gigabytes, for example.

Where there are greater volumes of data, several carriers are consequently required, necessitating additional expenditure both on soft- and hardware with respect to the reading-out of the data.

Storage and reading-out of data stored holographically in storage media of any material, such as in crystals or in organic or inorganic photo-refractive materials, for example, is possible in principle. The storage medium has considerable long-term stability and is insensitive to electromagnetic influences and high temperatures which may be up to 120° C, for example. The devices suitable for this are technically very complicated.

When reading in the information or data, it is necessary among other things to minimize the vibrations acting on the device, which can only be done by means of structural measures, such as positioning it in a basement and expensive foundations. The reading-out of the information or data is apt to be defective as even the smallest changes in the position of the storage media leads to a change in the intensities of transmitted components and of the corresponding component in the deflected part of the beam.

Devices of this kind are described in US 5,812,288, EP 0 817 201, GB 2,326,735, EP 0 632 348, US 5,007,690, US 5,519,651, US 5,727,226. All these devices are either very sensitive and where large volumes of data are concerned require a considerable number of different data carriers or, in the case of holographic data storage, are very expensive to implement and are defective with respect to the reading-out of the data.

A method for reading out holographically stored information is also known from US 5,822,263 A in which the readout beam is directed onto a crystal with the aid of a rotatably mounted reflector. The angle of incidence of the readout beam is adjusted by adjusting the angle of rotation of the reflector.

Finally, a method for reading out holographically stored data is known from EP 0 817 201 A2 in which a page indicator stored in addition to the holographic data is read out and imaged on the camera. The image accuracy of the page indicator is a gauge for the quality of the whole read-out hologram and the evaluation of the hologram is only performed if the image accuracy of the page indicator exceeds a preset limit value.

The object is therefore to provide a method and a device which make only very small demands on the environmental conditions, necessitate little expenditure and at the same time allow error-free reading-out of the stored data.

The object is achieved according to the invention by means of a method of the type previously defined comprising the features of the characterising clause of Claim 1 and also by means of a device of the type previously defined comprising the features of the characterising clause of Claim 3.

A processed beam of coherent electromagnetic radiation with any wavelength, preferably a laser beam, is transmitted through the storage medium containing the information, preferably a crystal, the intensity of the transmitted component of the beam is measured and the position of the storage medium mounted on a turntable is changed by means of a control and regulation system such that the intensity of the transmitted component of the beam is minimized and the information from the deflected component of the beam is read out by means of a camera.

The further development of the device is characterised by the fact that the changing of the position of the storage medium, which must be performed very rapidly but at the same time requires small displacement distances, is performed by means of the piezoelectric elements which are variable in their expansion very rapidly but are only variable a little in their expansion.

The change of the direction of rotation is not so rapid but is necessary with a considerable change of shape. It is performed with a stepping motor which does not change the angle of rotation of the table from the initial value to the final value as quickly as the piezoelectric elements change their length, a considerable change of shape nevertheless being possible by means of the displacement thereof.

Another development of the invention is characterised in that the processing of the information from the intensity measurement may be performed in accordance with very complex algorithms, unlike an analogue device.

Complex algorithms are necessary in the search for a minimum of the measured value where there are four variable control variables provided by the three piezoelectric elements and the stepping motor. The microcomputer is designed such that the programs may be varied by means of an additional port without removing and installing memories. This information processing is particularly effective if it is in the form of neural networks.

Another development of the invention is produced by joining together several storage media, or crystals, the number of which may reach the order of magnitude of 100 or more, thereby increasing the volume of stored information or data by a multiple. The beam or laser beam is masked with respect to the non-interrogated storage media. Since the focusing and masking of the beam or laser beam is done electronically, the access time to the individual information is not increased at all or only very negligibly.

The invention is explained in more detail in the following with the aid of embodiments and functional representations represented by the drawing, in which

Fig. 1 shows a schematic representation of the device for reading out the information from a crystal.

Fig. 2 shows a representation of the turntable with a crystal.

Fig. 3 shows a representation of the turntable from a direction of view perpendicular to the direction of view of the representation in Fig. 2.

Fig. 4 shows an arrangement of several crystals joined together.

Fig. 5 shows a circuit diagram for the interaction of the components of the control and regulation system.

Fig. 6 shows a representation of the mode of operation of the control and regulation system.

Fig. 1 shows schematically the individual components and their interaction with respect to the reading-out of data from a crystal.

The laser 1 produces a laser beam, which passes through a λ/2 plate 2, a polarizer 3, a beam expanding means and spatial frequency filtering means 4 until it is reflected by the mirror 5. It then passes through the collimator 6 and in the form of a processed laser beam 10 reaches the crystal 14 placed on the turntable 7.

In the crystal it is divided into a transmitted component of the laser beam 11 and a deflected component of the laser beam 12 which contains the information. The deflected component of the laser beam 12 is recorded by a CCD camera 8. The camera 8 converts the signals contained in the deflected component of the laser beam 12 into electronically represented signals which are read out via the computer link 21. The computer link 21 is a standard interface on computers and CCD cameras. The essential parts of this arrangement are known.

The transmitted component of the laser beam 11 impinges on an intensity measuring device 9 which converts the intensity of the beam into an electrical signal which represents the magnitude of the intensity 23.

According to the invention, the magnitude of the intensity 23 is used to change the controlling elements, provided by the three piezoelectric elements 16 and the stepping motor 15, such that the magnitude of the intensity is minimized.

Indicated in Fig. 2 is the representation of the turntable 7 with a crystal 14. The turntable 7 is turned in the direction of rotation 13 by means of the stepping motor 15 such that pre-selection of the region in which the information to be interrogated is located takes place in the crystal. When several crystals 17 joined together are used as indicated in Fig. 4, focusing and masking of the individual crystals is additionally performed.

The magnitude of the intensity 23 is changed by changing the piezoelectric elements 16 and by slight variation of the stepping motor 15.

Indicated in Fig. 3 is the representation of the turntable from a direction of view perpendicular to the direction of view of the representation in Fig. 2.

Indicated in Fig. 5 is the circuit diagram for the interaction of the components of the control and regulation system.

The transmitted component of the laser beam 11 is detected by means of the intensity measuring device 9. Via the signal line 18 for the intensity of the transmitted component, this information is passed on to the control and regulation system 19. The programs in the regulation system 19 may be changed via the port 22. The control and regulation system is a microcomputer which is additionally equipped with the necessary signal converters.

The piezoelectric elements 16 are adjusted via the piezoelectric element connections 21, and the stepping motor 15 is adjusted via the lines to the stepping motor control 20.

The mode of operation of the control and regulation system 19 is represented in Fig. 6.

The magnitude of the intensity 23 is dependent on all four control variables provided by the three piezoelectric elements 16 and the stepping motor 15.

The magnitude of the intensity 23 is represented as a function of a control variable 24.

The computer ascertains values of the intensity at setting 1 – 26 and setting 2 – 27 and other settings. It determines values for the magnitude of the intensity 23 and calculates new settings from these values until the minimum of the intensity 25 for all control variables 20 is reached.

This minimum of the intensity 25 of the transmitted component of the laser beam 11 ensures the error-free representation of the information in the deflected component of the laser beam 12.

Claims:

1. A method for reading out holographically stored information from a storage medium, more particularly a crystal,
characterised
in that a processed beam (10) of coherent electromagnetic radiation is transmitted through the storage medium (14) containing the information,
in that the intensity of the transmitted component (11) of the beam (10) is measured and
in that the position of the storage medium (14) mounted on a turntable (7) is changed by means of a control and regulation system (19) such that the intensity of the transmitted component (11) of the beam (10) is minimized and the information from the deflected component (12) of the beam (10) is read out by means of a camera device (8).

2. A method according to claim 1, characterised in that the turntable (7) is turned by means of a stepping motor (15) and the position of the storage medium (14) on this turntable (7) is changed by means of piezoelectric crystals (16).

3. A device for implementing a method for reading out holographically stored data from a storage medium, more particularly a crystal, in particular according to claim 1 or 2,
comprising a storage medium (14) containing the holographic information and
comprising a camera device (8) for reading out the information from the deflected component (12) of a beam (10) of coherent electromagnetic radiation,
characterised
in that a turntable (7) carrying the storage medium (14) is provided,
in that an intensity measuring device (9) for measuring the intensity of the transmitted component (11) of the beam (10) is provided and
in that a control and regulation system (19) for changing the position of the storage medium (14) mounted on the turntable in dependence on the intensity of the transmitted component (11) of the beam (10) is provided.

4. A device according to claim 3, characterised in that on the turntable (7) are arranged three piezoelectric crystals (16) which are equidistant from one another and each change the position of the storage medium (14) containing the information in the perpendicular direction or in a direction which preferably deviates from the vertical by a maximum of 2°.

5. A device according to claim 3 or 4, characterised in that the control and regulation system (19) consists of a microcomputer which processes the measured intensity of the transmitted component (11) of the beam (10) and the output of which are the signals which change the position of the storage medium (14) containing the information.

6. A device according to claim 5, characterised in that the program of the microcomputer may be changed during the operation.

7. A device according to claim 5 or 6, characterised in that the program used consists entirely or partly of neural networks or consists of program parts in which neural networks are simulated.

8. A device according to one of claims 3 to 7, characterised in that the holographic storage medium consists of several storage media joined together, more particularly crystals (14), which contain holographic information.

INTERNATIONAL SEARCH REPORT

Intern ial Application No
PCT/EP 00/02254

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G11B7/0065 G11C13/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G11B G11C G03H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
PAJ, INSPEC, EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 97 43669 A (QUANTUM CORP) 20 November 1997 (1997-11-20) the whole document	1,3
A	EP 0 817 201 A (LUCENT TECHNOLOGIES INC) 7 January 1998 (1998-01-07) cited in the application the whole document	1,3
A	DE 27 40 076 A (KOGYO GIJUTSUIN) 16 March 1978 (1978-03-16) the whole document	1,3

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

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Date of the actual completion of the international search	Date of mailing of the international search report
25 July 2000	01/08/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Holubov, C

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Interr ...nal Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to cla
A	PATENT ABSTRACTS OF JAPAN vol. 018, no. 621 (P-1832), 25 November 1994 (1994-11-25) & JP 06 236136 A (TOPPAN PRINTING CO LTD), 23 August 1994 (1994-08-23) abstract	

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